CLAIMS

That which is claimed is:

1. A surgical device, comprising:

a solid component having bound to a surface;

a first group of spherical particles wherein each particle of the first group has the same diameter as other particles in the first group with a margin of error of ±10% or less;

a second group of spherical particles wherein each particle of the second group has the same diameter as other particles in the second group with a margin of error of ±10% or less;

wherein the spherical particles of the first group and the spherical particles of the second group are comprised of a pharmaceutically active drug.

2. The device of claim 1, wherein the first group and the second group each comprise 100 or more particles and further wherein particles of the first group dissolve at a rate which is faster than a rate at which the particles of the second group dissolve.

3. The device of claim 1, wherein the pharmaceutically active drug is an antimicrobial.

4. The device of claim 3, wherein the antimicrobial is an antibiotic.

5. The device of claim 1, further having bound to the surface:

a third group of spherical particles wherein each particle of the third group has the same diameter as other particles in the third group with a margin of error of ±20% or less;

wherein the spherical particles of the third group are comprised of an antimicrobial drug.

6. The device of claim 5, wherein the third group comprises 100 or more particles and further wherein particles of the third group dissolve at a rate different from a rate at which the particles of the first and second groups dissolve.

7. The device of claim 1, wherein the particles are bound to surface indentations on the solid component.

8. The device of claim 7, wherein the solid component is a surgical screw.

9. The device of claim 1, further having bound to the surface:

a plurality of additional groups of spherical particles wherein the particles of each additional group has the same diameter as other particles in that group with a margin of error of ±20% or less; and

wherein the spherical particles of each additional group are comprised of an antimicrobial drug.

10. The device of claim 9, wherein each additional group comprises 100 or more particles and further wherein particles of each additional group dissolve at a rate different from a rate at which the particles of other groups dissolve.

11. The device of claim 5,

wherein the second group of particles have 1,000 square centimeters or more of surface area more than the first group of particles; and

wherein the third group of particles have 2,000 square centimeters or more of surface area more than the second group of particles.

12. The device of claim 5,

wherein the second group of particles have 5,000 square centimeters or more of surface area more than the first group of particles; and

wherein the third group of particles have 10,000 square centimeters or more of surface area more than the second group of particles.

13. The device of claim 5, wherein each group of spherical particles is bound to indentations on the surface of a metal screw.

14. The device of claim 9, wherein the particles of each group are bound to

circular indentations formed on upper surfaces of metal screw ridges.

15. The device of claim 9, wherein the particles of each group dissolve at a rate per unit of time which is different from a rate of dissolution of any other of the groups of particles by an amount of about 10% or more.

16. The device of claim 9, wherein the particles of each group dissolve at a rate per unit of time which is different from a rate of dissolution of any other of the groups of particles by an amount of about 25% or more.

17. The device of claim 16,wherein the pharmaceutically active drug is an antimicrobial.

18. The device of claim 9, wherein the spherical particles in each group have a diameter in a range of from about 40 micrometers to about 2 micrometers.

19. The device of claim 9, wherein the spherical particles in each group have a diameter in a range of from about 30 micrometers to about 4 micrometers.

20. A metal surgical screw with circular indentations in a surface, the indentations having bound thereto groups of particles, comprising:

a first group of spherical coated particles wherein each particle of the first group has an outer diameter substantially the same as other particles in the first group with a margin of error of ±20% or less and wherein the particles have a flowable liquid center surrounded by an outer coating; and

a second group of coated spherical particles wherein each particle of the second group has substantially the same diameter as other particles in the second group with a margin of error of ±20% or less and wherein the coated spherical particles of the second group are comprised of a liquid flowable core surrounded by an outer coating.

21. The surgical screw of claim 20, wherein the flowable liquid center of the spherical particles of the first group and the flowable liquid center of the spherical particles of the second group are comprised of a solution of a pharmaceutically active drug; and

wherein upon administration to a biological system the particles of the first group release the liquid core at a different time from the time at which the particles of the second group release the inner core.

22. The surgical screw of claim 20, further comprising:

a third group of coated spherical particles wherein each particle of the third group has the same diameter as other particles in the third group with a margin of error of ±20% or less and wherein the coated spherical particles of the third group are comprised of a liquid flowable core surrounded by an outer coating;

wherein the flowable liquid center of the spherical particles of the third group are comprised of a solution of a pharmaceutically active drug; and

wherein upon implantation in bone the particles of the third group release the liquid core at a different time from particles of the first and second groups.

23. The surgical screw of claim 20, further comprising:

a plurality of additional groups of coated spherical particles wherein the particles of each additional group have the same diameter as other particles in that group with a margin of error of ±20% or less and wherein the coated spherical particles of each additional group are comprised of a liquid flowable core surrounded by an outer coating; and

wherein the flowable liquid centers of the spherical particles of each additional group are comprised of a solution of a pharmaceutically active drug; and

wherein upon administration to a biological system the particles of each group releases the liquid core at a different time from other groups.

24. The surgical screw of claim 2, wherein an adhesive binds the particles to the surface.

25. The formulation of claim 20, wherein the pharmaceutically active drug is an antibiotic.

26. The device of claim 20, wherein the drug is chosen from an antibiotic, an antifungal and an antiviral compound.

27. The surgical screw of claim 20, wherein the coated spherical particles are produced by a process, comprising the steps of:

forcing a liquid formulation comprising a pharmaceutically active drug through a channel of a first feeding source in a manner which causes a stream of the liquid drug to be expelled from a first exit opening at a first velocity;

forcing a liquid comprising a coating material through a second channel concentrically positioned around the first channel in a manner which causes a stream of the liquid coating material to be expelled from a second exit opening at a velocity which is substantially the same as the first velocity whereby the stream of coating material is concentrically positioned around the stream of liquid drug;

forcing a gas through a pressure chamber surrounding the exit openings of the concentrically positioned first and second channels in a manner which causes the gas to exit the pressure chamber from an exit orifice positioned downstream of the concentrically positioned streams of liquid drug and coating material;

wherein the density of the liquid formulation comprising the pharmaceutically active drug is substantially the same as the density of the liquid comprising the coating material, and the gas focuses the concentrically positioned streams to a stable unified jet which flows out of the chamber exit orifice and breaks up into coated particles of the pharmaceutically active drug coated with the coating material.

28. The surgical screw of claim 27, wherein the stable unified jet comprises a diameter d_j at a given point A in the stream characterized by the formula:

$$d_j \cong \left(\frac{8\rho_l}{\pi^2 \Delta P_g} \right)^{1/4} Q^{1/2}$$

wherein d_j is the diameter of the stable unified jet, indicates approximately equally to where an acceptable margin of error is $\forall$ 10%, ρ_l is the average density of the liquid of the jet and ΔP_g is change in gas pressure of gas surrounding the stream at a given point A and Q is the total flow rate of the stable unified jet.

29. The surgical screw of claim 28, wherein d_j is a diameter in a range of about 1 micron to about 1 mm.

30. The surgical screw of claim 28,

wherein the stable unified jet has a length in a range of from about 1 micron to about 50 mm;

wherein the stable unified jet is maintained, at least in part, by tangential viscous stresses exerted by the gas on a surface of the jet in an axial direction of the jet; and

wherein the stable unified jet is further characterized by a slightly parabolic axial velocity profile.

31. The surgical screw of claim 28, wherein the particles of pharmaceutically active drug coated with coating material are characterized by having the same diameter with a deviation in diameter from one particle to another in a range of from about ∀3% or less.

32. The surgical screw of claim 31, wherein the deviation in diameter from one particle to another is in a range of from about ∀1% or less.

33. The surgical screw of claim 28, wherein a coated particle of the first group has a diameter in a range of about 0.1 micron to about 100 microns and other particles of the first group have the same diameter as the given particle with a deviation of about ∀3% or less; and

wherein $\Delta P = P_o - P_1$, the difference in pressure through the chamber exit orifice, is equal to or less than twenty times the surface tension of the liquid comprising the coating material with the gas, divided by the radius of the stable unified jet.

34. The surgical screw of claim 20,

wherein the second group of particles have 1,000 square centimeters or more of surface area more than the first group of particles; and

wherein the third group of particles have 2,000 square centimeters or more of surface area more than the second group of particles.

35. The surgical screw of claim 20,

wherein the second group of particles have 5,000 square centimeters or more of surface area more than the first group of particles; and

wherein the third group of particles have 10,000 square centimeters or more of surface area more than the second group of particles.

36. A method, comprising:

inserting a surgical screw into a bone wherein the surgical screw has bound to its surface a plurality of spherical particles which particles comprise an antimicrobial compound; and

allowing the antimicrobial compound to diffuse into the bone in an area surrounding the surgical screw.